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**Research Report 1701**

# Relationship Between Platoon Gunnery Training and Live-Fire Performance

**Bruce S. Sterling**
U.S. Army Research Institute

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Reduced training resources require the military to increasingly depend on simulators for routine training. Regardless of how inexpensive a simulator may be, however, the simulator is useless if it does not enhance performance on the actual equipment. This research demonstrates a relationship between training on platoon gunnery simulators and live-fire gunnery performance for U.S. Army tank and Bradley Fighting Vehicle (BFV) platoons. Because these data replicated previous findings for both simulators, results suggest that both tank and BFV platoons may profit from training on platoon gunnery simulators.

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**Research Report 1701**

# Relationship Between Platoon Gunnery Training and Live-Fire Performance

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## FOREWORD

The U.S. Army is making increased use of simulators in training its mounted forces. However, in many cases there is little empirical research concerning the effectiveness of these simulators, or how use of and proficiency on these simulators relates to performance on the actual equipment.

The research described in this report was performed when the author worked in the Training Analysis Division of the Seventh Army Training Command of the U.S. Army, Europe (USAEUR). This research was performed on a noninterference basis to provide commanders information concerning how use of the Tank and Bradley Platoon Gunnery Trainers (PGTs) related to live-fire gunnery performance.

The research was not formally reported in its entirety and was not widely distributed out of the Seventh Army Training Command. This research is relevant to the mission of the U.S. Army Research Institute for the Behavioral and Social Sciences' Armored Forces Research Unit (AFRU) at Fort Knox, KY. Therefore, this research is published by AFRU to more widely distribute findings relevant to the armored forces community.

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The author of this report gratefully acknowledges the critical assistance provided by Mr. Stephan Arrington of the Seventh Army Training Command's Training Analysis Division. His help in conceptualizing measures of Platoon Gunnery Trainer and live-fire gunnery performance, and developing computer programs to produce these measures was invaluable. The author also thanks Mr. Kenneth Vlasek for help in data reduction and programming.

RELATIONSHIP BETWEEN PLATOON GUNNERY TRAINING AND LIVE-FIRE PERFORMANCE

## EXECUTIVE SUMMARY


Research Requirement:

Reduced training resources require the U.S. Army to increasingly depend on simulators for routine training. Regardless of how efficient simulators are, they are not effective if they do not enhance performance on the actual equipment. This research investigates the relationship between tank and Bradley Fighting Vehicle (BFV) platoons' use of and proficiency on gunnery simulators and live-fire gunnery performance.

Procedure:

This research was conducted on a strictly non-interference basis. Measures reflecting platoons' use of and proficiency on tank and BFV Platoon Gunnery Trainers (PGTs) were collected. These PGT measures were correlated with measures of performance on platoon live-fire (Table XII) gunnery.

Findings:

For tank platoons, it was found that performance on all three of the frequently run PGT exercises related to live-fire performance. Also, the number of PGT exercises run and passed between gunneries related to improvement between gunneries in live-fire performance. These research findings were confirmed on two replications. For BFV platoons, it was found that performance on one of the three frequently run exercises related to live-fire performance. Also, the number of PGT exercises run prior to the current gunnery related to live-fire gunnery performance, on two replications of the research.

Utilization of Findings:

This research demonstrates small but consistent relationships between training on platoon gunnery simulators and live-fire performance across replications. Results suggest that platoon gunnery simulators may be effective for platoon-level gunnery (Table XII) training.

RELATIONSHIP BETWEEN PLATOON GUNNERY TRAINING AND LIVE-FIRE PERFORMANCE

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# RELATIONSHIP BETWEEN PLATOON GUNNERY TRAINING AND LIVE-FIRE PERFORMANCE

The program to prepare the U.S. Army for the Twenty-First Century, Force XXI Training Program (FXXI-TP), stresses the use of simulators and simulations for training (Burnside, Quinkert, Black & Maggart, 1995). A major reason for the use of simulators and simulations is that they require fewer resources than traditional field training. These resources not only include dollar driven resources such as fuel, spare parts, ammunition and the personnel to supply these resources, but also environmental resources such as terrain damage and range time (an issue because of limited live-fire hours in order to restrict noise pollution). Simulators and simulations also have other advantages for training. These advantages include facilitating standardization of training, providing automated feedback and enabling the training of tasks that cannot be trained in the field due to safety constraints.

The U.S. Army has used simulators for armored forces gunnery training since the mid 1980's. The Unit-Conduct of Fire Trainer (U-COFT) assists in training crew gunnery skills for M1 series tanks and Bradley Fighting Vehicles (BFVs). The U-COFT is a high fidelity representation of the commander and gunner work stations. Commanders and gunners view simulated targets through their sights, and must perform all gunnery procedures necessary to engage targets, just as they would on the actual vehicle. Enemy vehicles appear to burn when a catastrophic kill is achieved. The mobility and firepower kills are not represented in U-COFT. The instructor/operator (I/O) plays the roles of driver and loader (responding to the vehicle commander), as well as platoon leader (giving and receiving information). The U-COFT collects gunnery performance data automatically, and provides the commander and gunner with feedback in the form of printouts of their performance. The I/Os provide verbal feedback on command and control (e.g., fire commands) and reporting procedures. Crews advance through a matrix of exercises, depending on their gunnery performance. See Hughes, Butler, Sterling & Burglund (1987) and Hughes, Morales-Steigley & Musser (1990) for detailed descriptions of the M1 and M2/3 U-COFT respectively.

In the early 1990's the U. S. Army fielded the Platoon Gunnery Trainers (PGTs) for tanks and BFVs. In January of 1992 the Seventh Army Training Command (7th ATC) changed the tank PGT located at Vilseck, Federal Republic of Germany (FGR) from a simulator designed to prepare platoons for the Canadian Army Trophy competition to a simulator designed to train general platoon gunnery skills. Also, in the second quarter of fiscal year (FY) 93, the Bradley PGTs located at Vilseck and Baumholder, FRG were ready for training. A second tank PGT was ready for training at Schweinfurt, FRG in the first quarter of FY94.

The PGT is essentially four linked U-COFTs. Commanders and gunners can see the vehicles in their own platoons as well as other vehicles on the battlefield. The platoon leader must direct his platoon as in live-fire gunnery or combat. He must give movement and fire commands and provide reports to the company commander. Platoons can move only on a predetermined path, but platoon leaders can give commands to control when and how fast the platoon moves. Platoons run fixed exercises and receive printed feedback on gunnery performance. Platoons also receive verbal (after action review or AAR) feedback on command and control issues from the senior I/O, or unit personnel, such as the company commander. Kraemer and Wong (1992) provide a detailed description of the tank PGT.

Tank and BFV gunnery simulators undoubtedly use less resources than training with the actual vehicle. They also provide standardized training and automated feedback. However, one cannot consider them to be effective training devices unless there is some evidence suggesting they enhance performance on the actual vehicle. Research conducted with both the tank U-Coft (Hughes et al., 1987) and BFV U-COFT (Hughes et al., 1990) demonstrate that various measures of U-COFT use and proficiency are related to crew gunnery (Table VIII) performance. Additionally, Kraemer & Wong (1992) showed that platoon gunnery-like performance in a tank platoon gunnery simulator improved over the number of exercises run. Demonstrating improved performance on the training simulator itself is important. However, for tank and BFV platoon gunnery simulators, the critical research question concerns whether degree of use and/or proficiency on platoon gunnery simulators relates to live-fire platoon gunnery performance.

The research presented in this report is an attempt to demonstrate a relationship between tank and BFV PGT training and platoon live-fire performance. This research is strictly correlational, as the guidance in performing the research was for it to be "transparent" (i.e., unobtrusive) to the units. Thus there was no possibility of using the experimental method to provide the conclusion that PGT training "causes" improvements in gunnery skills. We can only establish relationships (or lack thereof) between PGT training and live-fire performance.

This report presents two types of data for both tank and BFV platoons. The first is a comparison of performance on certain individual PGT exercises run shortly before firing live-fire platoon gunnery to actual platoon live-fire gunnery performance (Table XII or TXII). The second is the relationship of the overall number of PGT exercises run and successfully completed to TXII performance. The report presents the tank PGT research first, followed by the BFV research.

## TANK PGT RESEARCH

### Performance on Specific PGT Exercises and Tank TXII (TTXII)

The purpose of comparing performance on specific PGT exercises and TTXII performance was to determine if there were any individual PGT exercises specifically related to TTXII performance. The reason for this comparison was to help U.S. Army decision makers determine potential exercises that they might use as "gates" for TTXII. That is, if there were certain exercises that related particularly well to TTXII performance, the command might require platoons to achieve a certain level of performance on these exercises prior to live-firing TTXII. The hypothesis was that performance on the PGT exercise most similar to TTXII (day hasty defend/attack) would be correlated with TTXII live-fire performance.

#### Method

##### Sample

All data for the following analyses were collected from Grafenwoehr Training Area (GTA), where U.S. Army, Europe (USAREUR) tank and BFV platoons conduct live-fire gunnery biannually. Data used in the following analyses were collected from October 1992 through September 1993 (FY93). There were 177 four-crew platoons that used the PGT and fired TTXII at GTA in FY93. Because of the unobtrusive nature of the research, no surveys were administered. Therefore, demographic data on the members of the platoons were unavailable.

##### Measures

Measures of performance for PGT consisted of percentage of vehicle, troop and total (vehicle plus troop) targets killed in the exercise. Vehicle targets were mostly tanks and fighting vehicles (e.g., BMPs) which required use of the main gun in order to kill them. However, platoons could kill some vehicle targets (e.g., trucks) with the main gun or coaxial (COAX) machine gun.

Performance measures for TTXII consisted of main gun, troop and total (main gun plus troop) targets hit. Percentage of targets hit for targets presented and targets represented were calculated. Table 1 presents information on PGT and TTXII data collected, by PGT exercise.

Every platoon had 42 main gun and 18 troop targets represented (less target failures). However, platoons had differing numbers of main gun targets presented. Main gun targets not hit on the first band were presented again on the second, and if necessary, on some tasks, a third band. Representing only the number of targets not hit on previous bands is called a depleting scenario. The TTXII scenario presented troop targets only once.

For example, if the scenario presented 14 main gun targets in the first band, and the platoon hit 8, the remaining 6 targets were presented in the second band. Assuming a platoon hit all 6 targets in the second band, the platoon was credited with 14 targets hit out of 14 represented. However, the platoon was scored as hitting 14 out of 20 targets (14 + 6) presented. That is, the platoon had 20 "chances" to hit 14 targets. Percentage of targets hit divided by targets represented was the actual score for platoons, for both tank and BFV platoon gunnery.

Table 1
Means and Standard Deviations of Performance Measures by Tank PGT Exercise

| Measures | Day Hasty Defense (n=53) | | Day Hasty Attack (n=53) | | Day Hasty Defend Attack (n=156) | |
|---|---|---|---|---|---|---|
| (Percentage PGT Targets Killed) | M | SD | M | SD | M | SD |
| All Targets | 47.7 | 9.6 | 57.4 | 11.8 | 58.9 | 9.5 |
| Vehicle Targets | 42.1 | 10.3 | 57.0 | 12.0 | 54.8 | 10.1 |
| Troop Targets | 69.3 | 14.7 | 58.5 | 19.4 | 72.5 | 13.4 |
| (Percentage TTXII Targets Hit) | | | | | | |
| All Targets Presented | 58.0 | 9.9 | 57.7 | 9.5 | 56.4 | 11.1 |
| All Targets Represented | 84.2 | 7.6 | 85.0 | 7.2 | 83.5 | 8.1 |
| Main Gun Targets Presented | 54.5 | 12.0 | 55.1 | 10.5 | 53.4 | 12.5 |
| Main Gun Targets Represented | 89.5 | 10.0 | 92.3 | 6.9 | 90.0 | 9.2 |
| Troop Targets | 72.0 | 11.1 | 68.3 | 12.0 | 68.9 | 12.1 |

No latency data on TTXII (e.g., time from target exposure to first round fired or opening time) were collected. Training Analysis Division (TAD) personnel experimented with collecting various latency measures, but several technical complications (e.g., lack of suitable software for computers on the range) prevented consistent collection of latency data. Opening times and kill times (time from exposure of target until it was killed, only for targets that were killed) were available on PGT, but because there were no comparable times on TTXII, these measures were omitted from the analyses.

## Procedure

This part of the research used data only for platoons training on PGT "in density." That is, tank and BFV battalions came to the GTA biannually to conduct crew and platoon live-fire. Crews trained on preliminary gunnery tables, fired crew gunnery (Table VIII, or TVIII), then trained on advanced tables and fired platoon gunnery (TTXII). Generally, units used PGT after crew gunnery and prior to TTXII. Any PGT exercises run after TTXII were excluded from the analyses.

For these platoons, PGT personnel gave copies of PGT printouts for exercises run "in density" to TAD. These printouts contained the number of main gun and troop targets presented and killed for each run of each exercise. These data were then entered into a database and checked for accuracy. If a platoon ran an exercise more than once, the average performance for all iterations was computed; i.e., total targets killed divided by total targets presented for all iterations of that exercise.

Similarly, range personnel supplied TTXII (live-fire) score sheets to TAD. These score sheets contained the number of targets presented and hit for each presentation of each task of TTXII. Data were entered and error checked. Then the measures of TTXII proficiency described above were calculated from this data.

Measures of a platoon's PGT performance on a given exercise were paired with measures of that platoon's TTXII (live-fire) performance for that gunnery density. This pairing was limited to exercises run by at least ten different platoons, to eliminate analyzing data for exercises run by only a handful of platoons. Then, all cases for a given exercise were combined for all of FY93. For example, if 12 platoons firing TTXII ran an exercise in the first quarter, 10 platoons firing TTXII in the second quarter, no platoons in the third quarter, and 14 platoons firing TTXII in the fourth quarter, then that exercise would have a total of 36 cases available for analysis.

## Results

There were only three commonly run PGT exercises (i.e., PGT exercises run by more than 10 platoons firing TTXII in any quarter of FY93). These were the basic exercises of day hasty defense, day hasty attack, and day hasty defend/attack. Table 2 shows the number of platoons running various PGT exercises by quarter. Pearson correlations between PGT and TTXII performance for these exercises are displayed in Table 3. These numbers in Table 2 represent all platoons running the exercises in that quarter, not just those firing TTXII. Therefore, these numbers do not necessarily add to the number of platoons represented in the Pearson correlations in Table 3.

In Table 3, correlations between like measures for PGT and TTXII are shown. That is, total targets killed in PGT are correlated with total targets (presented and represented) hit on TTXII. Vehicle targets killed in PGT are correlated with main gun targets hit on TTXII. Also, troop targets killed in PGT are correlated with troop targets hit in TTXII.

As shown, for all three PGT exercises, there were small but statistically significant correlations ($p < .05$, two-tailed) between percentage of total targets killed in PGT and percentage of total targets (presented) hit on TTXII. Additionally, for two of the three PGT exercises (day hasty attack and day hasty

defend/attack), there were small but statistically significant correlations between percentage of vehicle targets killed in PGT and percentage of main gun targets (presented) killed on TTXII.

Table 2
Tank PGT Platoon Exercises Run by Quarter, FY93

| | Number of Platoons | | | | |
|---|---|---|---|---|---|
| Exercise | 1Q | 2Q | 3Q | 4Q | Σ |
| Day Hasty Defense | 25 | 7 | 19 | 14 | 65 |
| Night Hasty Defense | 2 | 1 | 3 | 4 | 10 |
| Day Hasty Attack | 17 | 16 | 14 | 7 | 54 |
| Night Hasty Attack | 1 | -- | -- | 1 | 2 |
| Day Deliberate Attack | -- | 1 | -- | 9 | 10 |
| Night Deliberate Attack | -- | -- | -- | 1 | 1 |
| Rain Deliberate Attack | 1 | -- | -- | -- | 1 |
| Day Hasty Defend/Attack (Version 1) | -- | -- | -- | 2 | 2 |
| Night Hasty Defend/Attack (Version 1) | -- | 1 | -- | -- | 1 |
| Day Hasty Defend/Attack (Version 2) | 61 | 57 | 27 | 24 | 169 |
| Night Hasty Defend/Attack (Version 2) | -- | 7 | 2 | 4 | 13 |
| Fog Hasty Defend/Attack | -- | 1 | -- | -- | 1 |
| Haze Hasty Defend/Attack | -- | 3 | -- | -- | 3 |
| Snow Hasty Defend/Attack | 1 | 2 | -- | -- | 3 |
| Rain Hasty Defend/Attack | 1 | -- | -- | -- | 1 |
| Day Deliberate Attack/Delay to Subsequent Battle Position | 6 | 1 | -- | -- | 7 |
| Haze Deliberate Attack/Delay to Subsequent Battle Position | -- | 1 | -- | -- | 1 |
| Locally Created Exercise | -- | -- | -- | 2 | 2 |

None of the correlations between percentage of troop targets killed on PGT and hit on TTXII were statistically significant.

As previously stated, one of the goals of these analyses was to find if any particular exercises were sufficiently predictive of TTXII performance as to be used as a "gate". Based on preliminary research on FY92 data (the year the PGT was fielded in USAREUR) and subject matter expert (SME) opinion, the PGT staff tentatively chose an exercise as a kind of "gate". Platoons were required to run (although not achieve any

gunnery skills. Thus, in the third and fourth quarters of FY93, platoons were no longer required to run the day hasty defend/attack exercise prior to firing TTXII.

This led to a natural experiment. We compared performance on the day hasty defend/attack exercise and TTXII for the first two and last two quarters of FY93. These results, reported in Table 4, show percentage of PGT total targets killed were significantly correlated with percentage of TTXII total targets (presented) hit only in the last two quarters of FY93, when platoons were no longer required to run the exercise.

Table 3
Correlations Between PGT Exercise Performance and TTXII Performance

| PGT Performance (Percentage Kills) | TTXII Performance (Percentage Hits) | | | | |
|---|---|---|---|---|---|
| | All Targets | | Main Gun Targets | | Troop Targets |
| | Presented | Represented | Presented | Represented | |
| Day Hasty Defense (n=53) | .2707* | .1618 | .2058 | .1153 | .0194 |
| Day Hasty Attack (n=53) | .4379* | .2559 | .2772* | .1224 | .2669 |
| Day Hasty Defend/ Attack (n=156) | .2469* | .1446 | .2523* | .1157 | .0262 |

*=P<.05,2 Tailed Test

Similarly, percentage of PGT vehicle targets killed were significantly related to percentage of TTXII main gun targets (presented) hit only in the last two quarters of FY93. These results imply that using only one exercise as a "gate," especially if units can train on that exercise, is not good practice. Units will "train the test," and performance on this exercise will no longer be predictive of TTXII performance.

The PGT performance was more related to TTXII targets presented than represented. Of the seven statistically significant correlations reported in Tables 3 and 4, all involved percentage of TTXII targets presented.

Relationships between percentage of total targets killed in PGT and total targets hit in TTXII for the three PGT exercises are illustrated in Figures 1 to 4. Data for the day hasty defend/attack exercise are divided into the first and last half of FY93.

Relationships between percentage of total targets killed in PGT and total targets hit in TTXII for the three PGT exercises are illustrated in Figures 1 to 4. Data for the day hasty defend/attack exercise are divided into the first and last half of FY93.

Table 4
Correlations Between PGT and TTXII Performance for Day Hasty Defend/Attack Exercise

| PGT Performance (Percentage Kills) | TTXII Performance (Percentage Hits) | | | | |
|---|---|---|---|---|---|
| | All Targets | | Main Gun Targets | | Troop Targets |
| | Presented | Represented | Presented | Represented | |
| 1st & 2nd Qtrs (n=109) | .1316 | .0673 | .1314 | .0494 | .0068 |
| 3rd & 4th Qtrs (n=47) | .3848* | .1934 | .3955* | .1242 | .0343 |

*=P<.05,2 Tailed Test

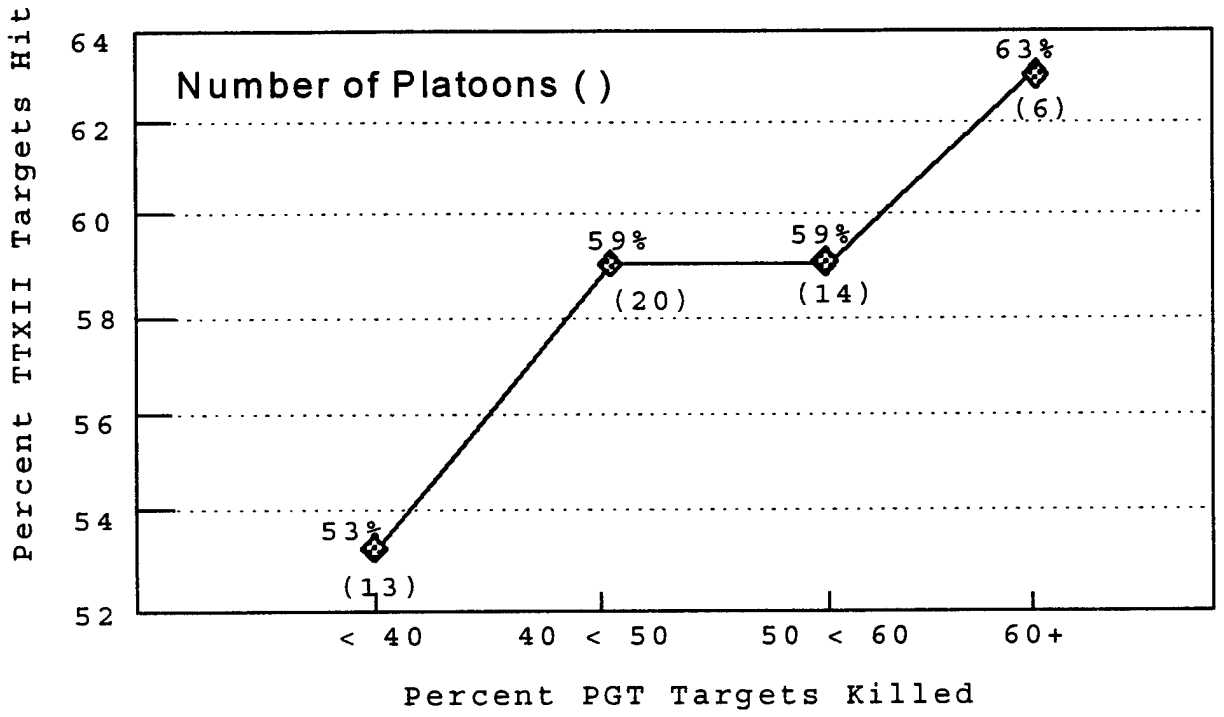


Figure 1. Performance on PGT Exercise Day Hasty Defense and TTXII Performance

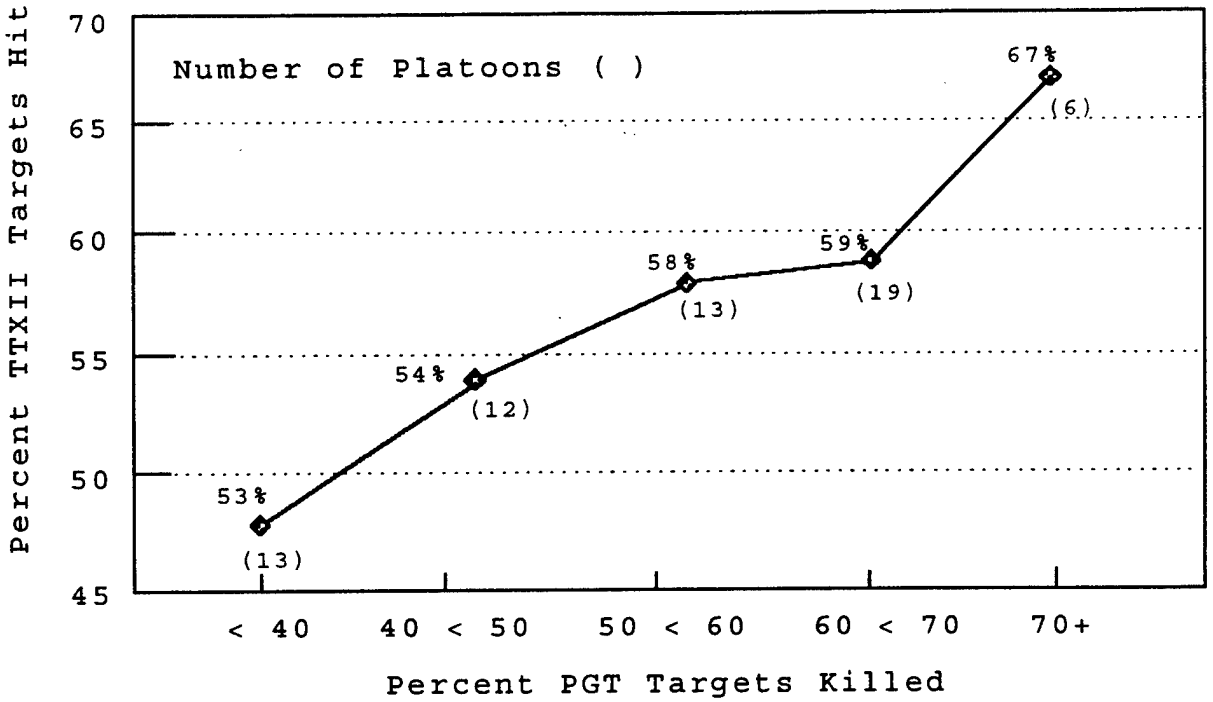


Figure 2. Performance on PGT Exercise Day Hasty Attack and TTXII Performance

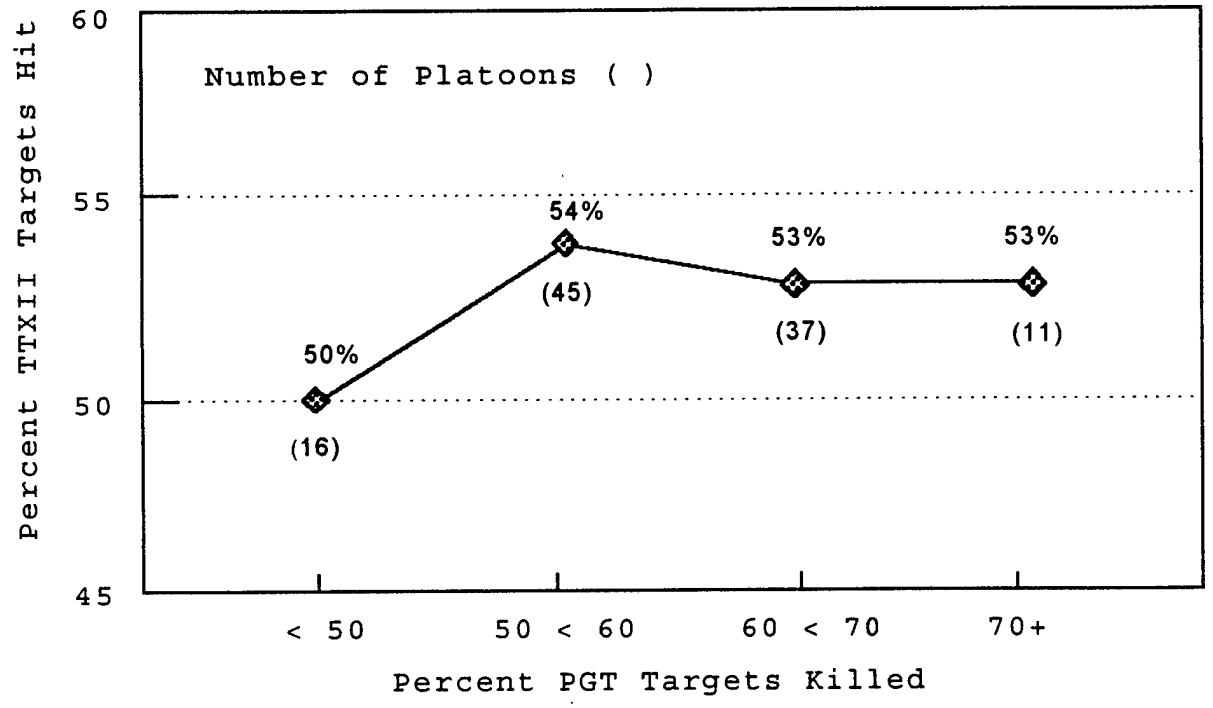


Figure 3. First & Second Quarter Performance on PGT Exercise Day Hasty Defend/Attack and TTXII Performance

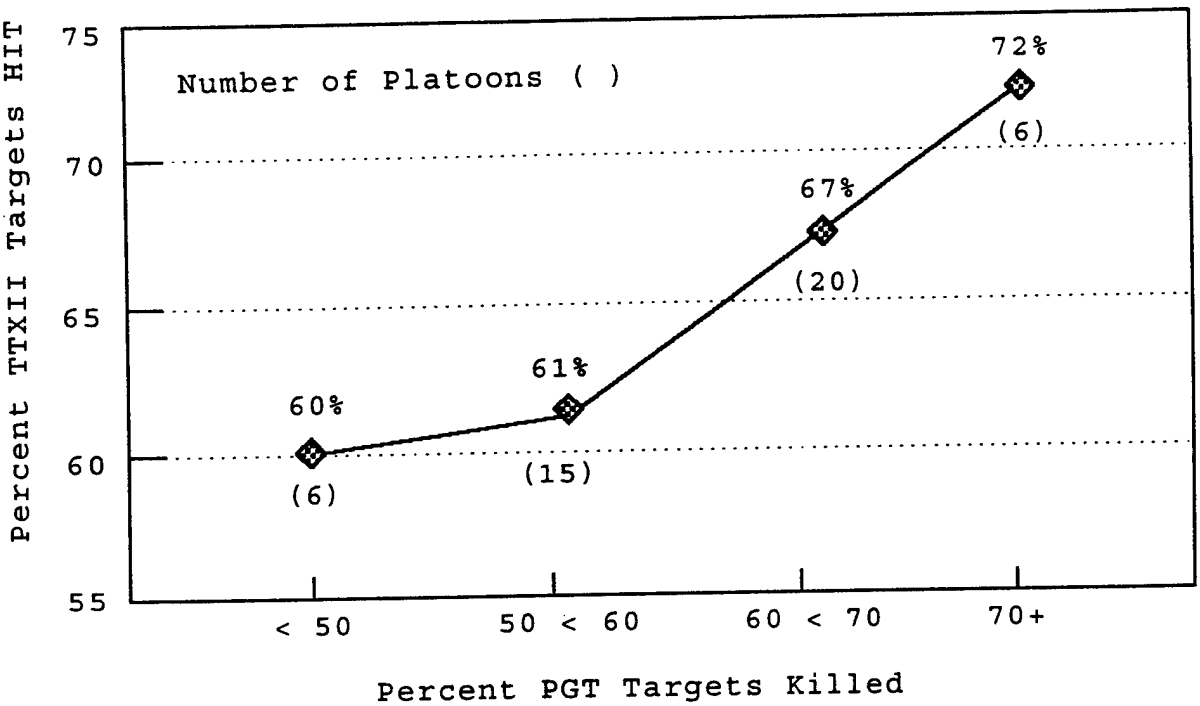


Figure 4. Third & Fourth Quarter Performance on PGT Exercise Day Hasty Defend/Attack and TTXII Performance

Total PGT Exercises Run and Passed and TTXII Performance

Another purpose of this research was to determine the relationship between the overall use of and proficiency on PGT and TTXII performance. The reason for this comparison was to assist U.S. Army decision makers in determining if there was an optimal number of exercises to run or successfully complete between gunneries. This information could provide an alternate form of "gate" in terms of total use of and proficiency on PGT required prior to live-firing TTXII, versus performance on a specific exercise. This alternative was especially relevant after it was found that platoons will "train the test" if one limits the "gate" to a specific exercise.

The impetus for this analysis came from some data and insights provided by PGT I/Os and supervisory personnel. In the first and second quarters of FY93, PGT personnel began recording the total number of exercises run and successfully completed (defined in the method section below) by three battalion sized units who were frequent users of PGT. Their insight was that platoons that ran and passed more PGT exercises between gunneries seemed to display better sustained gunnery performance on TTXII.

This insight is supported by previous research on simulator performance and crew level gunnery. Hughes et al. (1987) found

that the more U-COFT exercises run and levels advanced through the matrix between gunneries, the more improvement in crew gunnery.

Preliminary analyses using number of exercises run and passed supplied by PGT personnel, and measures of sustainment of gunnery skills from TAD records confirmed the judgment of PGT personnel (Sterling 1993a). Collection of data on all exercises run by all platoons, whether in or out of "density" was then initiated. This data collection effort allowed attempts to replicate the preliminary findings based on our own database in the fourth quarter of FY93. This replication of the findings was again attempted at the request of the Commander-in-Chief (CINC), USAREUR in the third quarter of FY94. The hypothesis in both cases was that platoons running and passing more exercises between gunneries would have better sustainment of gunnery performance.

## Method

### Sample

The PGT data for the first replication of this research were collected from the tank PGT site located at GTA (Vilseck). The PGT data for the second replication of this research were collected from both the tank PGT sites located at GTA and Schweinfurt, FRG. Most of the PGT exercises were run at GTA. All measures of live-fire performance were collected at GTA. Data for the first replication were collected from units that fired TTXII in the second and fourth quarters of FY93. Data for the second replication were collected from units that fired TTXII in the first and third quarters of FY94. There were 26 platoons in the first replication and 35 in the second replication.

### Measures

The PGT use and proficiency measures included total number of exercises run and total number of exercises successfully completed (passed) between biannual gunnery "densities." Exercises run includes all platoon level exercises run (regardless of outcome) between gunneries. Total number of exercises passed includes all exercises run on which platoons received a score of 70 or greater. Score roughly corresponded to percentage of targets killed. The score was weighted so that vehicle targets accounted for 70 percent of the score and troop targets accounted for 30 percent. This weighting was similar to the weighting of TTXII where main gun targets composed 70 percent of the score and troop targets composed 30 percent.

Measures of percentage hits for targets represented and presented were identical to those described above. However, we defined sustainment of gunnery skills as the difference between current gunnery performance and performance in the last gunnery. Thus, a negative score represented a decline in performance (in

terms of percentage of targets hit) from last gunnery to current gunnery, while a positive score represented an increase in performance from the previous gunnery.

Table 5 contains data on PGT measures of use and proficiency as well as TTXII performance for both replications of the research.

## Procedure

For this analysis PGT personnel gave printouts of all exercises run by any unit to TAD. For each exercise, identifying information and score were entered into a database and error checked. Then measures of PGT use and proficiency described above were computed. The PGT data was merged with measures of changes in TTXII data for platoons live-firing TTXII in the quarters mentioned.

## Results

Pearson correlations between number of exercises run and passed in PGT between densities and change in TTXII performance between densities are reported in Table 6. Results show a positive relationship between number of PGT exercises run and passed and change in TTXII performance for several measures of TTXII performance. In general, the more exercises run and passed, the more improvement in TTXII performance.

Table 5
Means and Standard Deviations of Measures by Replication: Tank Data

| PGT Measures | Replication | | | |
|---|---|---|---|---|
| | First (n=26) | | Second (n=35) | |
| | M | SD | M | SD |
| Exercises Run | 4.6 | 2.5 | 7.8 | 5.5 |
| Exercises Passed | 1.9 | 2.3 | 3.8 | 2.9 |
| (Change in Percentage TTXII Targets Hit) | | | | |
| All Targets Presented | 9.1 | 13.8 | 2.9 | 10.9 |
| All Targets Represented | 3.0 | 10.1 | -11.5 | 13.6 |
| Main Gun Targets Presented | 11.0 | 14.8 | .4 | 14.7 |
| Main Gun Targets Represented | 3.2 | 10.1 | -20.2 | 17.8 |
| Troop Targets | 1.9 | 15.4 | 8.2 | 13.1 |

Table 6

Correlations Between Number of PGT Exercises Run and Passed Between Densities and Change in TTXII Performance

| PGT Performance (Percentage Kills) | Change in TTXII Performance (Percentage Hits) | | | | |
|---|---|---|---|---|---|
| | All Targets | | Main Gun Targets | | Troop Targets |
| | Presented | Represented | Presented | Represented | |
| 1st Replication (n=26) | | | | | |
| Run | .5147* | .4759* | .4889* | .3895* | .4361* |
| Passed | .4708* | .3400 | .5133* | .4054* | .1371 |
| 2nd Replication (n=35) | | | | | |
| Run | .2051 | .4127* | .3040 | .5101* | -.1639 |
| Passed | .3403* | .6289* | .3570* | .6532* | .1134 |

*=P<.05,2 Tailed Test

The number of PGT exercises passed was significantly related to change (improvement) in TTXII total and main gun targets (presented) hit, in both replications. The number of PGT exercises run was significantly related to change (improvement) in all measures of TTXII performance in the first replication and change (improvement) in total and main gun targets (represented) hit in the second replication.

Figure 5 demonstrates the relationship between total PGT exercises passed between gunneries and improvement on TTXII in terms of percentage of targets presented hit, for data from the second replication.

PGT measures were about equally related to both measures of (change in) percentage of TTXII targets hit. There were seven significant correlations with targets represented and six with targets presented.

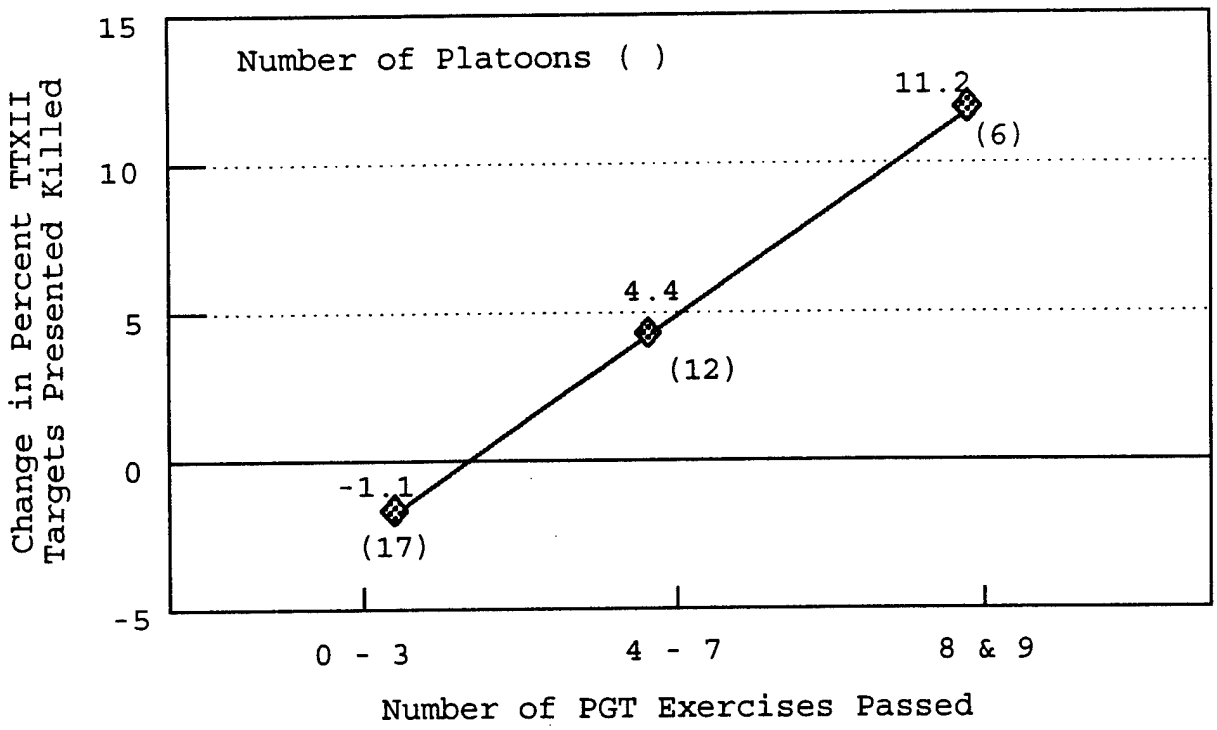


Figure 5. PGT Exercises Passed Between Gunneries and Change in TTXII Performance

## BRADLEY PGT RESEARCH

### Performance on Specific PGT Exercises and Bradley TXII (BTXII)

The purpose for these analyses is the same as that described above in the comparable section on tank PGT research. Because crews were running very basic exercises in the Bradley PGT, we did not hypothesize a relationship between any specific exercise(s) and BTXII performance. This analysis was exploratory.

#### Method

##### Sample

All data for this portion of the research were collected from GTA. The PGT data were collected from the Bradley PGT site in Vilseck and the live-fire data from the GTA ranges. Data were collected from July through September of 1994 (fourth quarter, FY94). This research included data on 30 platoons that used PGT and fired BTXII.

Measures

Measures of PGT exercise performance are identical to those discussed in the previous section on tank PGT research.

Measures of BTXII performance, like measures of TTXII performance, also included percentage hits of targets presented and represented. However, unlike TTXII, BTXII does not use a depleting scenario. That is, all targets were presented on all bands. For example, if a platoon hit 4 of 10 targets on the first band, and 4 more (of ten again) on the second band, range personnel scored the platoon as hitting 8 of 10 targets represented but 8 of 20 targets presented. In the rare instances of platoons hitting more than the number of targets represented, they were scored as hitting only the number of targets represented.

The only data recorded for BTXII was number of targets hit and number of times (bands) the targets were presented. Therefore, unlike TTXII, it was impossible to distinguish between platoons that hit 6 of 10 targets in the first band and 2 in the second and platoons that hit 2 of 10 targets in the first band and 6 in the second. In BTXII, both would be scored as hitting 8 of 10 targets represented and 8 of 20 targets presented.

The reason that BTXII did not have a depleting scenario was the large number of troop targets. With the technology available, it was too difficult to design a system that could keep track of targets hit on each band. Although the number of main gun targets was not large, the same system was used to control both main gun and troop targets. Thus, the depleting scenario was not used for either type of target.

Most troop targets in BTXII were engaged by dismounted troops. Because the BFV PGT did not train dismounted troops, we did not score targets that could have been engaged by dismounted troops. At the time of this research, there were a few troop targets that platoons were only allowed to engage with the COAX. These were the only troop targets that were scored in this research. Unlike TTXII, troop targets in BTXII were presented on successive bands.

In general BTXII had an average of around 26 main gun targets represented and an average of about 19 troop (COAX) targets.

In summary, measures of BTXII performance were percentage hits of total, main gun, and troop (COAX) targets, presented and represented. Table 7 contains data on measures of PGT and BTXII performance, by PGT exercise.

Table 7
Means and Standard Deviations of Performance Measures by Bradley PGT Exercise

| Measures (Percentage PGT Targets Killed) | Day Hasty Defense (n=21) | | Night Hasty Defense (n=16) | | Day Hasty Attack (n=20) | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD |
| All Targets | 70.1 | 8.1 | 71.5 | 12.9 | 67.9 | 9.7 |
| Vehicle Targets | 69.3 | 9.7 | 76.7 | 12.0 | 74.5 | 11.1 |
| Troop Targets | 73.5 | 10.6 | 52.5 | 21.5 | 52.2 | 13.5 |
| (Percentage BTXII Targets Hit) | | | | | | |
| All Targets Presented | 58.1 | 10.7 | 62.7 | 16.9 | 63.8 | 12.6 |
| All Targets Represented | 76.8 | 9.7 | 83.7 | 10.7 | 80.9 | 10.1 |
| Main Gun Targets Presented | 62.2 | 15.6 | 62.6 | 18.5 | 66.3 | 16.6 |
| Main Gun Targets Represented | 88.0 | 9.1 | 91.3 | 8.8 | 92.0 | 6.7 |
| Troop Targets Presented | 53.6 | 15.0 | 62.3 | 21.2 | 61.0 | 16.3 |
| Troop Targets Represented | 63.2 | 18.2 | 73.9 | 20.5 | 66.9 | 17.8 |

## Procedure

Collection and reduction of measures of PGT and BTXII performance was performed exactly the same way as described in the previous section on tank PGT research.

## Results

There were only three PGT exercises run by ten or more platoons. These were day hasty defense, night hasty defense, and day hasty attack. Table 8 shows all exercises run and the number of platoons running each exercise. Pearson correlations between performance on the three frequently run exercises and BTXII are shown in Table 9. Not all platoons running a particular PGT exercise in Table 8 live-fired BTXII. Therefore, the number of platoons running an exercise in Table 8 may not equal the number of platoons represented in the correlations for that exercise in Table 9.

Table 8
Bradley PGT Platoon Exercises Run, Fourth Quarter FY93

| Exercise | Number of Platoons |
|---|---|
| Day Hasty Defense | 24 |
| Night Hasty Defense | 22 |
| Fog Hasty Defense | 1 |
| Rain Hasty Defense | 1 |
| Day Hasty Attack | 20 |
| Night Hasty Attack | 2 |
| Fog Hasty Attack | 1 |
| Day Hasty Defense/Delay | 2 |
| Day Deliberate Attack | 2 |
| Night Deliberate Attack | 1 |
| Day Hasty Defend/Attack | 6 |
| Night Hasty Defend/Attack | 4 |
| Day Deliberate Attack/Defend | 3 |

Table 9
Correlations Between PGT Exercise Performance and BTXII Performance

| PGT Performance (Percentage Kills) | BTXII Performance (Percentage Hits) | | | | | |
|---|---|---|---|---|---|---|
| | All Targets | | Main Gun Targets | | Troop Targets | |
| | Presented | Represented | Presented | Represented | Presented | Represented |
| Day Hasty Defense (n=21) | -.0623 | .0845 | -.0722 | -.0501 | .0769 | -.1888 |
| Night Hasty Defense (n=20) | .1267 | .2577 | -.0196 | .3269 | .0057 | .1685 |
| Day Hasty Attack (n=20) | .5085* | .3275 | .2731 | .4586* | .0846 | -.1068 |

*=P<.05,2 Tailed Test

Results indicate that there are statistically significant relationships between performance on only one of these three exercises and BTXII performance. The more total and vehicle targets killed in the day hasty attack PGT exercise, the more total targets presented and main gun targets represented were hit on BTXII.

Figure 6 depicts the relationship between percentage of total targets killed in PGT and percentage of total targets hit on BTXII for the day hasty attack PGT exercise. Additionally, performance on the night hasty defense PGT exercise showed a

small relationship to percentage hits on BTXII targets presented. Had the number of platoons been comparable to the numbers in the tank platoon research, these correlations would have reached statistical significance.

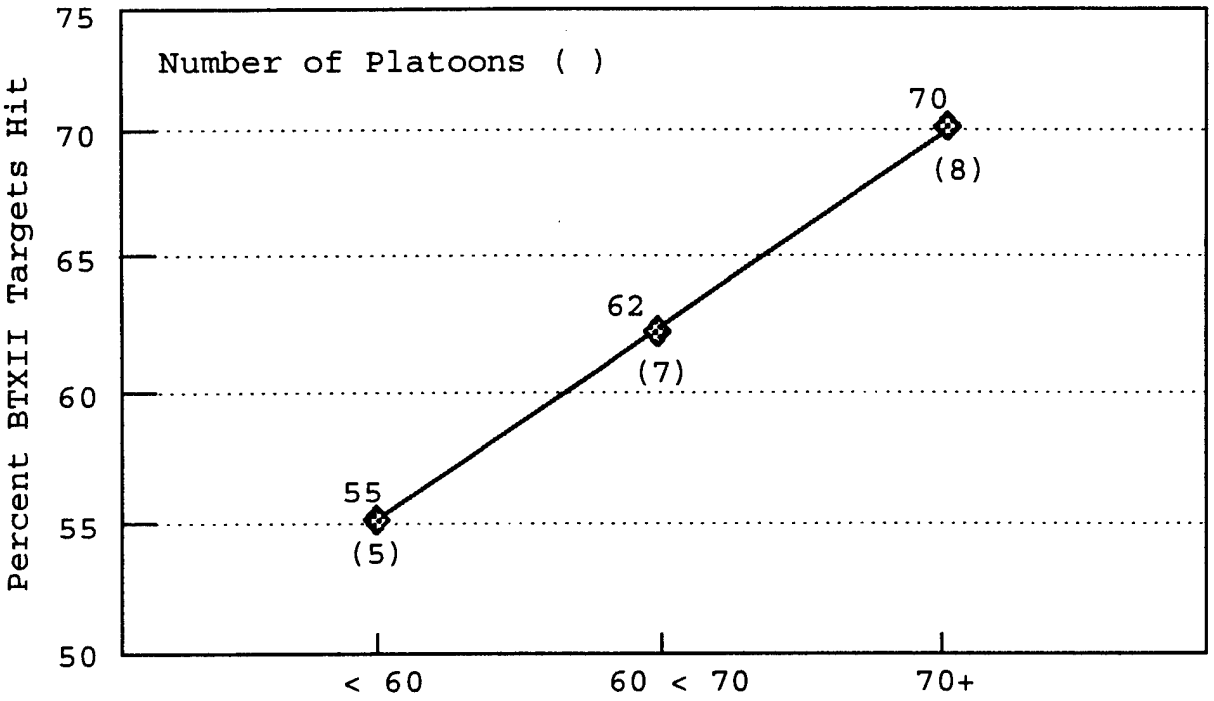


Figure 6. Performance on PGT Exercise Day Hasty Attack and BTXII Performance

Total PGT Exercises Run and Passed and BTXII Performance

The rationale for this research was similar to the rationale given in the previous section for the tank PGT research. A difference, however, was that SMEs here recommended restricting examination of PGT exercises run to those run during the quarter of the current gunnery versus those run between gunneries. Units ran most of these exercises while they were in "density." One possible reason for this recommendation is that observations of crew gunnery suggest that turnover between densities is greater for BFV crews. We hypothesized that the more exercises run and passed in the current quarter, the better the performance on BTXII.

## Method

### Sample

Data were collected at GTA (Vilseck) and, for the second replication, also Baumholder, FRG. All live-fire data were collected at GTA. The first sample was 31 platoons that fired BTXII in the fourth quarter of FY93. This included the 30 platoons in the sample for the research above plus one platoon that did not use PGT in the fourth quarter. The second sample consisted of 36 platoons that fired BTXII in the third quarter of FY94, when the research was replicated at the request of the CINC, USAREUR.

### Measures

PGT performance included all exercises run and successfully completed (passed) in the current quarter. As with the tank PGT, platoons had to achieve a score of 70 to pass. Scores were based on a weighted percentage of vehicle and troop targets killed, similar to tank PGT scores.

For the first sample, measures of BTXII performance were identical to those described above in the individual exercise section. For the second sample, measures were limited to main gun targets only. The reason for this was that all troop targets could now be engaged by dismounted troops. Because PGT did not train dismounted troops, the troop target measure for BTXII were eliminated.

Table 10 contains data on measures of PGT use and proficiency as well as BTXII performance.

Table 10
Means and Standard Deviations of Performance Measures by Replication: Bradley Data

| PGT Measures | Replication | | | |
|---|---|---|---|---|
| | First (n=31) | | Second (n=36) | |
| | M | SD | M | SD |
| Exercises Run | 3.9 | 1.5 | 3.0 | 1.6 |
| Exercises Passed | 2.4 | 1.5 | 1.7 | 1.2 |
| (Percentage TXII Targets Hit) | | | | |
| All Targets Presented | 62.2 | 14.2 | -- | -- |
| All Targets Represented | 80.8 | 11.0 | -- | -- |
| Main Gun Targets Presented | 64.5 | 15.9 | 50.4 | 12.3 |
| Main Gun Targets Represented | 88.3 | 10.1 | 81.5 | 13.1 |
| Troop Targets Presented | 59.7 | 19.9 | -- | -- |
| Troop Targets Represented | 71.5 | 20.6 | -- | -- |

## Procedure

Collection and reduction of measures of PGT and BTXII performance was performed exactly the same way as described in the comparable section on tank PGT research. The PGT data was collected from Bradley PGT sites at Vilseck (and Baumholder for the second replication).

## Results

Pearson correlations between number of PGT exercises run and passed in the current quarter and BTXII performance in the current quarter are reported in Table 11. For both replications, there was a relationship between number of exercises run and BTXII performance.

Table 11
Correlations Between Number of PGT Exercises Run and Passed and BTXII Performance

| PGT Exercises | BTXII Performance (Percentage Hits) | | | | | |
|---|---|---|---|---|---|---|
| | All Targets | | Main Gun Targets | | Troop Targets | |
| | Presented | Represented | Presented | Represented | Presented | Represented |
| 1st Replication (n=31) | | | | | | |
| Run | .3742* | .2409* | .4085* | .4068* | .1670 | .0131 |
| Passed | .4420* | .4441* | .3878* | .5072* | .3088 | .2043 |
| 2nd Replication (n=36) | | | | | | |
| Run | -- | -- | .3578* | .3892* | -- | -- |
| Passed | -- | -- | -.0155 | -.0843 | -- | -- |

*=P<.05,2 Tailed Test

For the first replication, number of PGT exercises passed was related to all measures of total and main gun BTXII performance. Number of PGT exercises run was related to percentage hits of total (presented) targets and main gun (presented and represented) targets on BTXII.

For the second replication, there was a statistically significant correlation between number of PGT exercises run and both measures of BTXII main gun performance. Figure 7 illustrates the relationship between total exercises run in PGT and percentage of main gun targets represented hit on BTXII, for the second replication.

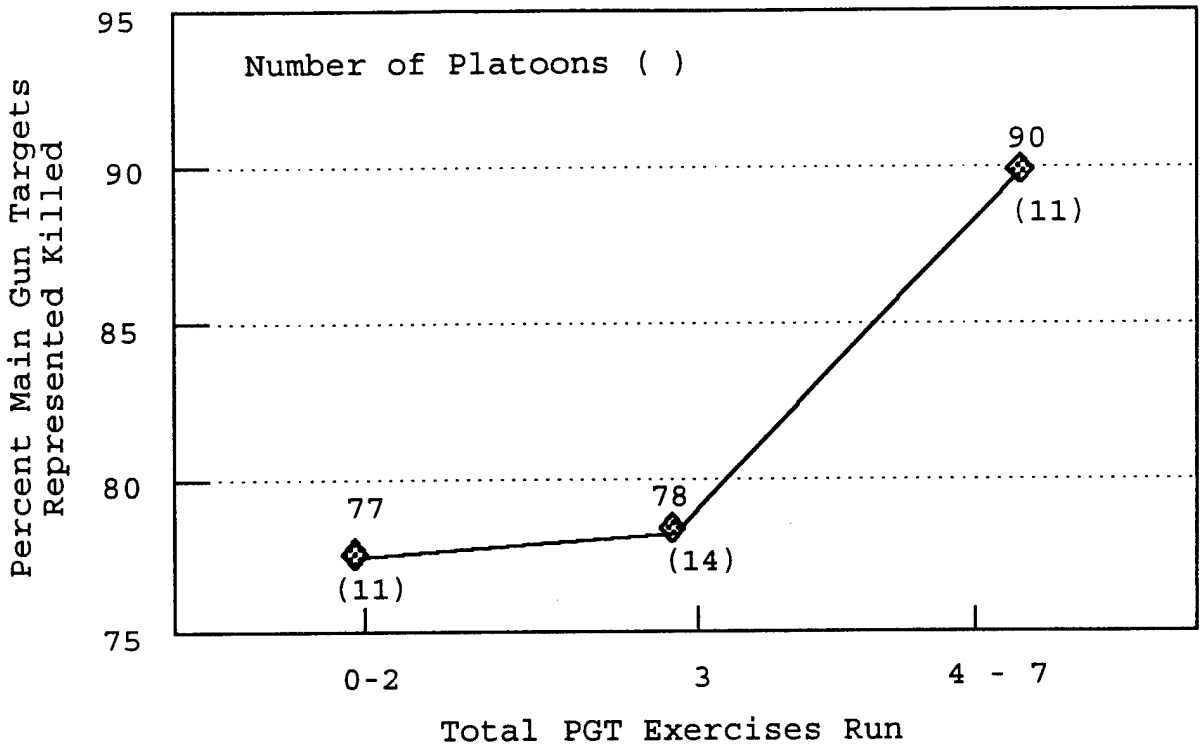


Figure 7. PGT Exercises Run and BTXII Main Gun Performance

## DISCUSSION

### Summary of Results

Relationships between measures of PGT proficiency and use and platoon gunnery performance were found for both tank and BFV platoons. Concerning performance on specific PGT exercises, there were relationships between performance on all three frequently run tank PGT exercises and percentage of total targets hit in tank platoon gunnery. One of these exercises was the one hypothesized to relate to TTXII performance. For BFV platoons, there was a relationship between performance on only one of the three most frequently run exercises and platoon gunnery performance. Performance on the PGT day hasty attack exercise related to percentage of total and main gun targets hit. Performance on troop targets in PGT exercises was not related to performance against troop targets in platoon gunnery for either tank or BFV platoons.

There were also relationships between measures of overall use of and proficiency on the tank and Bradley PGTs and platoon gunnery performance. For tank platoons, as hypothesized, the more PGT exercises run and passed between gunneries, the more improvement of gunnery performance between gunneries for total and main gun targets in both replications. For BFV platoons,

also as predicted, the more exercises run during the current gunnery the more main gun targets hit in platoon gunnery on both replications. Only one significant correlation occurred (in tank platoons) between PGT use and performance against troop targets in TTXII.

## Limitations of the Research

It may be somewhat surprising that any relationships were found given the conditions under which the research was conducted. Although the relationships are not strong (only a few reached the .50 range) they are fairly consistent.

The PGT is only one component of a unit's gunnery program. While limited space in local training areas precludes much training as a platoon, units conduct varying amounts of home station crew gunnery training (e.g. U-COFT, crew proficiency tests) with varying effectiveness.

Also, there was no control over the way units used the PGT. In certain PGT AARs, leaders emphasized command and control substantially more than number of targets killed, while others emphasized gunnery more than command and control. There was no control over the order that platoons ran PGT exercises during density, how many other exercises the platoon ran before or after a given exercise, or the timing of the PGT exercises. For instance, in measuring the relationship between performance on a given exercise and platoon gunnery performance, there was no control over whether that was the last PGT exercise run prior to gunnery, or whether several other PGT exercises were run prior to gunnery. In examining the relationship between total exercises run or passed, no control was exerted over whether platoons ran or passed three iterations of the same exercise or three different exercises, and whether the exercises were massed or spaced.

In addition, there is some variation from one platoon gunnery run to another. While all platoons have the same number of targets represented (at least for tank platoons), poor tactical decision making by a platoon leader may result in firing more difficult tasks (e.g., some targets may appear only once).

Finally, there was no control over, or even the ability to quantify, platoon turnover. Range personnel did not collect crew rosters for platoon gunnery. Range personnel did collect crew rosters for crew gunnery, but not every crew fired crew gunnery every time the platoon fired platoon gunnery. Therefore, platoon battle rosters could not be constructed from crew battle rosters. Some crew rosters were collected from the PGT. Examination of changes in these rosters between gunneries suggested that turnover for crew commander and gunner positions was about 50 percent between gunneries. Thus, about half of each tank platoon remained the same between gunneries.

Given all these deficiencies, the research nonetheless shows a relationship between PGT use and proficiency, under actual field conditions reflecting how units use the PGT. Similar results can reasonably be expected whenever the PGT is used for training under actual field conditions.

This research also did not determine the extent to which PGT training is related to live-fire command and control. It is known that in addition to gunnery training, the PGT is also a command and control trainer. Kraemer and Wong (1992), using Armor Officer Basic Course students, found that command and control measures improve over exercises run in the tank PGT. Research in the field also found that command and control measures improved over PGT exercises run for both tank (Sterling, 1993b) and BFV (Sterling, 1994) platoons. An attempt was made to examine relationships between command and control skills in PGT and platoon gunnery, but range personnel collected no such data during live-fire gunnery.

## Areas for Future Research

The contribution of the PGT to platoon gunnery should be explored further. As discussed earlier, the PGT is only part of a unit's gunnery program. A unit's gunnery program generally includes several types of training. Training may include individual training, such as Tank or Bradley Crew Gunnery Skills Test, and crew training, such as U-COFT or Tank or Bradley Crew Proficiency Test. Perhaps some sort of simulated platoon gunnery at a local training area, or even command and control training in Simulation Networking (SIMNET) may be included in the gunnery program. As suggested above, each of these types of training may account for a portion of the variance in platoon gunnery.

The limitations of the present research demonstrate the need to develop a method of routinely capturing data on these other types of gunnery related training that occur in units. The Standard Army After Action Review System (STAARS) and Army Digital Training Library (ADTL), as reflected in the Warfighter XXI (WFXXI) strategy may assist in the effort to routinely collect a wide variety of training data.

The WFXXI strategy (Blackwell, 1995) is the plan to train Army units for the challenges of the next century. The WFXXI strategy consists of five components. The first is the Standard Army Training System (SATS). The SATS is an automated tool to help commanders determine what tasks to train and how to train these tasks. The second component is the training support packages (TSPs). These contain all materials necessary to conduct structured training, such as orders, graphics, instructions for individuals playing opposing, higher and adjacent forces, etc. This type of training is designed to ensure that the tasks the commander has chosen to train are trained in the given scenario. The third component is the training aids, devices, simulators and simulations (TADSS) on

which the structured training is conducted. The fourth component is STAARS. This component is an automated tool to assist in recording data from the standard training exercises, and prepare an automated AAR. The final component is the ADTL, which is a composite of data from virtual (e.g., PGT), constructive (e.g., Janus) and live (e.g., live-fire) simulations.

The PGT had a sort of automated AAR, in that gunnery (but not command and control) data were automatically recorded and provided to the platoon by way of a printout. In FY94, TAD succeeded in prompting a modification to the PGT contract whereby the gunnery data automatically recorded by the PGT were also downloaded to a personal computer attached to the PGT. The data could periodically be copied on a diskette and forwarded to TAD. Then TAD ran programs designed to extract specific information from this data and link it to platoon TXII performance.

Such a training library database, including a variety of training data such as simulator (virtual) data and live data (reflecting performance on the actual weapon system), can be useful. This data would be especially meaningful if based on use of standardized training support packages. Researchers could use regression type statistics to determine the amount of variance accounted for in live-fire gunnery performance by different types of gunnery training. Researchers could determine how those relationships may change over time. Also, the database may help to provide information to Army decision makers concerning the optimum mix of simulator and other types of training for a given level of live performance on the actual system.

This research contains a concrete example of useful information from such an ADTL. The data shows how the relationship between the day hasty defend and attack PGT exercise and platoon gunnery performance strengthened once it was no longer a required exercise. This suggests that it is unwise to use a specific exercise as a "gate," at least unless platoons are prevented from "training the test." The data instead suggests that overall use of and proficiency on PGT may be a better measure of readiness for live-fire gunnery.

In addition, controlled research on PGT training and live-fire performance would also be useful. Although this type of research will be difficult to conduct in a field setting, it may be possible in an institutional setting. Here, researchers could control use of PGT, personnel turnover and the performance (dependent) measure to a degree that would likely prove impossible in a field setting.

Although the research discussed here has shown a replicated relationship between PGT training and platoon gunnery performance, additional research along the lines suggested above would be useful in further determining the true nature and size of this relationship.

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